Working document presented to the Benchmark Workshop on the development of MSY advice for category 3 stocks using Surplus Production Model in Continuous Time (WKMSYSPiCT)

Data revision workshop – 17th to 19th November 2020

Black-bellied anglerfish (*Lophius budegassa*) in divisions 8c and 9a (Cantabrian Sea, Atlantic Iberian waters): data compilation

ank.27.8c9a

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1. Introduction and history of the assessment

This document compiles the information available for *Lophius budegassa* in ICES divisions 8c and 9a. Data available for this stock was last revised in 2018, during the WKANGLER benchmark (ICES, 2018a).

A stochastic production model in continuous-time (SPiCT) (Pedersen and Berg, 2017) was proposed for the assessment of *L. budegassa* in WKANGLER, using, as input data, landings and commercial LPUEs for three fleets. This model was considered more reliable than the prior model used, ASPIC (Prager, 1994), benchmarked in 2012 (ICES, 2012). Given the uncertainties regarding the absolute levels of biomass and fishing pressure, the 2018 assessment was rejected. SPiCT estimates were considered as indicative of trends only and advice followed guidelines for category 3.2 stocks, with proxy reference points (ICES, 2018b).

SPiCT diagnostics show some autocorrelation for index 1 - PT-TRC9A (the Portuguese trawl crustacean series), which has been considered not meaningful. This auto-correlated residual pattern may reflect spatiotemporal changes in the distribution or may indicate transitory changes in catchability (ICES, 2018a).

2. Data available

2.1. Stock ID

WKANGLER (ICES, 2018a) concluded that there may be some structure within the NE Atlantic area for both *Lophius* species but there is also some degree of mixing, and that there is not sufficient information to change the current stock areas. This stock (ank.27.8c9a) distributes in the Cantabrian Sea and Atlantic Iberian waters down to Gulf of Cadiz (Figure 1).

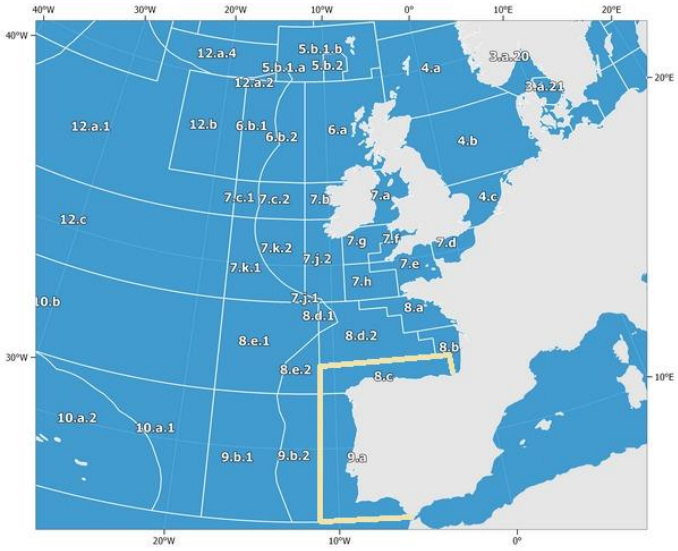

Figure 1. *Lophius budegassa* in ICES divisions 8c and 9a.

2.2. Biological information

Growth parameters

Reliable growth estimates are lacking for this species. A new method to estimate growth parameters based on length frequency distribution was presented to WKANGLER, using data for ICES area 7 (Batts and Gerritsen, 2018 WD). Table 1 summarizes preliminary growth parameters for *L. budegassa* estimated under this study and also for the congener *L. piscatorius.*

Table 1. *Lophius budegassa* in ICES divisions 8c and 9a. Growth parameters for *L. budegassa* and *L. piscatorius*. Adapted from WKANGLER (ICES, 2018a).

Species	ICES area	Sex	Linf (cm)	k (y^{-1})	t0 (y^{-1})	n	TL range (cm)	Ref.
L. budegassa	7	combined	119.84	0.118	-0.816	6720	4-90	Batts and Gerritsen (2018)
L. piscatorius	7,8	combined	140.00	0.11	na	na		Landa et al. (2008)
L. piscatorius	7	combined	162.31	0.088	-0.894	979	5-125	Landa et al. (2012)

Maturity

Maturity data for ICES divisions 8c and 9a is available from three studies (Table 2).

Table 2. *Lophius budegassa* in ICES divisions 8c and 9a. Maturity information.

ICES Area	Sex	L_{50} (cm)	Ref
8c9a	F	53	Landa et al. (2014)
8c9a	M	36	Landa et al. (2014)
9a	F	56	Azevedo (1996)
9a	M	37.6	Azevedo (1996)
9a	F	53.6	Duarte et al. (2001)
9a	M	38.6	Duarte et al. (2001)

2.3. Fisheries dependent data

2.3.1. Landings

Quarterly landing data are reported by ICES division and métier by Spain (since 1978), Portugal (since 1978) and France (since 2002). Portuguese landings were TAC constrained from 2005 to 2011 and low landings were registered in the 4th quarters during that time period. Since 2010 that Portuguese landings in the 1st quarter are lower given the prohibition to land *Lophius* species in January and February (to protect these species during the reproductive season). Landings by division and fleet are presented in Table 3 and Figure 2. Landings for this stock mostly derive from trawl fleets operating in ICES Divisions 8c and 9a and from the Portuguese artisanal fleet (mainly trammel nets) operating in ICES division 9a (Figure 3). Gillnet fisheries in 8c also contribute to a great fraction of the catches. Spanish catches in southern 9a (Gulf of Cadiz) are from trawlers and, in the last three years, represented between 3 and 5% of total catches of the stock.

Table 3. *Lophius budegassa* in ICES divisions 8c and 9a. Tonnes landed by the main fishing fleets for 1978-2019 as determined by the Working Group. Adapted from ICES (2020b).

	Div. 8c							Div. 9a							Div. 8c+9a	
	SPAIN			FRANCE				SPAIN			PORTUGAL					
Year	Trawl	Gillnet	Others	Trawl	Gillnet	Others	TOTAL	Trawl	Gillnet	Others	Trawl	Artisanal	TOTAL	SUBTOTAL	Unallocated/Non reported	TOTAL
1978	n/a	n/a					n/a	248			n/a	107	355	355		355
1979	n/a	n/a					n/a	306			n/a	210	516	516		516
1980	1203	207					1409	385			n/a	315	700	2110		2110
1981	1159	309					1468	505			n/a	327	832	2300		2300
1982	827	413					1240	841			n/a	288	1129	2369		2369
1983	1064	188					1252	699			n/a	428	1127	2379		2379
1984	514	176					690	558			223	458	1239	1929		1929
1985	366	123					489	437			254	653	1344	1833		1833
1986	553	585					1138	379			200	847	1425	2563		2563
1987	1094	888					1982	813			232	804	1849	3832		3832
1988	1058	1010					2068	684			188	760	1632	3700		3700
1989	648	351					999	764			272	542	1579	2578		2578
1990	491	142					633	689			387	625	1701	2334		2334
1991	503	76					579	559			309	716	1584	2162		2162
1992	451	57					508	485			287	832	1603	2111		2111
1993	516	292					809	627			196	596	1418	2227		2227
1994	542	201					743	475			79	283	837	1580		1580
1995	924	104					1029	615			68	131	814	1843		1843
1996	840	105					945	342			133	210	684	1629		1629
1997	800	198					998	524			81	210	815	1813		1813
1998	748	148					896	681			181	332	1194	2089		2089
1999	565	127					692	671			110	406	1187	1879		1879
2000	441	73					514	377			142	336	855	1369		1369
2001	383	69					452	190			101	269	560	1013		1013
2002	202	74		10	1	0	288	234	0	0	75	213	522	810		810
2003	279	49		9	0	0	338	305	0	0	68	224	597	934		934
2004	251	120		14	5	0	391	285	0	0	50	267	603	993		993
2005	273	97		26	9	0	405	283	0	0	31	214	527	933		933
2006	323	124		12	1	0	460	541	0	0	39	121	701	1161		1161
2007	372	68		4	1	0	444	684	0	0	66	111	861	1306		1306
2008	386	70		5	1	0	462	336	0	0	40	119	495	957		957
2009	301	148		3	1	0	454	172	0	0	34	114	320	774		774
2010	319	81		2	1	0	403	197	0	0	70	84	351	754		754
2011	214	115	32	3	0	0	364	157	60	98	75	119	510	874	74	948
2012	161	83	22	2	0	0	268	109	40	90	156	370	765	1033	109	1141
2013	221	135	14	4	1	0	375	95	55	90	100	258	598	973	98	1071
2014	187	126	7	5	2	0	326	120	47	4	116	286	572	898	100	998
2015	233	141	1	2	2	0	380	103	62	2	126	222	515	895	152	1047
2016	203	118	5	2	2	0	330	103	79	2	120	257	560	889	125	1014
2017	163	153	0	1	3	0	319	109	62	1	68	302	542	861		861
2018	186	156	1	7	9	0	359	126	37	1	52	185	402	761	11	773
2019	137	117	0	1	2	0	259	109	49	1	43	135	337	595	73	669

n/a: not available

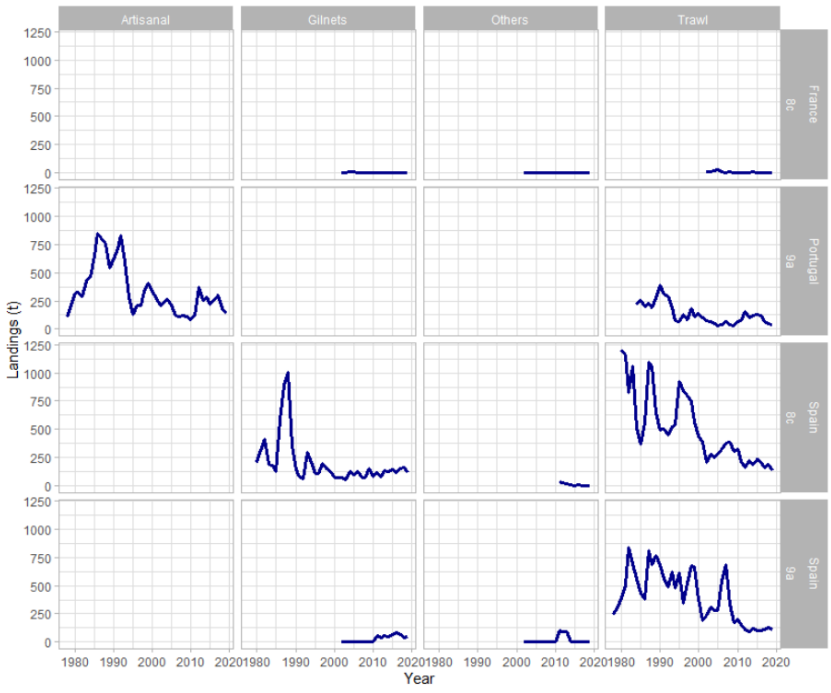

Figure 2. *Lophius budegassa* in ICES divisions 8c and 9a. Tonnes landed by the main fishing fleets for 1978-2019 as determined by the Working Group.

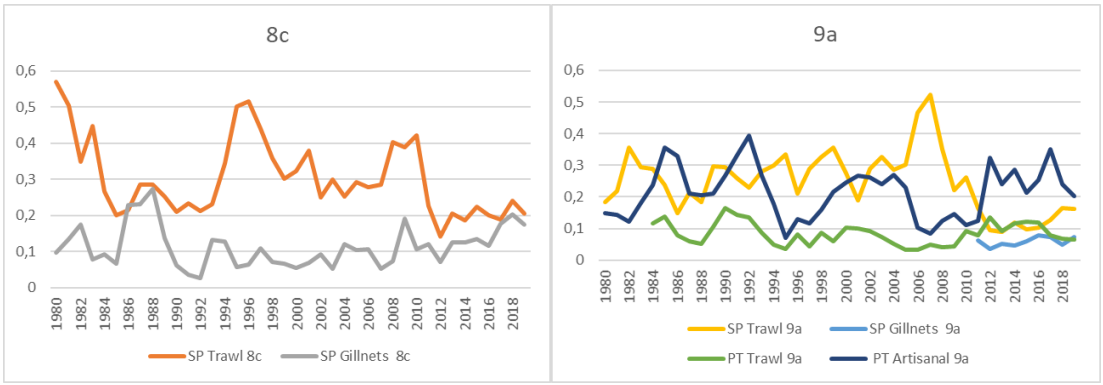

Figure 3. *Lophius budegassa* in ICES divisions 8c and 9a. Proportion of total landings of each fleet, by ICES division (1978-2019).

This species is usually landed with the white anglerfish and is being recorded together in the ports' statistics. Therefore, estimates of each species in Spanish landings from divisions 8c and 9a and Portuguese landings of Division 9a are derived from their relative proportions in market samples. Besides official landings, there is a series of unreported landings for the period 2011–2019 allocated to Spain, which represents from 1 to 15% of total landings. The unreported landings are considered realistic and are included in the stock assessment. There is a latitudinal gradient observed in the proportion of these species, with *L. budegassa* proportions increasing remarkably from the northern to the southern landing ports.

2.3.2. Discards

The assessment currently excludes discards, which have been considered negligible for Portuguese fleets and low for Spanish fleets. Spain provides an annual estimate of discards in weight for trawl since 1994 (with gaps for years 1995, 1996, 1998, 2001 and 2002) and for gillnets fleet since 2013 (Table 5). With exception of 2006 and 2010, discards for the trawl and gillnet fleets represent very low proportions of the total catches in each year.

Table 5. *Lophius budegassa* in ICES divisions 8c and 9a. Weight and percentage of discards for Spanish trawl and gillnet fleets.

TRAWL

Year	Weight (t)	CV	% Trawl Catches	% Total Catches
1994	6,1	24,4	0,6	0,4
1995	n/a	n/a	n/a	n/a
1996	n/a	n/a	n/a	n/a
1997	21,3	35,2	1,6	1,2
1998	n/a	n/a	n/a	n/a
1999	19,7	43,7	1,6	1,0
2000	8,7	35,1	1,1	0,6
2001	n/a	n/a	n/a	n/a
2002	n/a	n/a	n/a	n/a
2003	1,4	n/a	0,2	0,1
2004	10,9	n/a	2,0	1,1
2005	9,3	n/a	1,7	1,0
2006	114,0	n/a	11,7	9,8
2007	4,2	n/a	0,4	0,3
2008	4,9	n/a	0,7	0,5
2009	23,3	n/a	4,7	3,0
2010	63,5	n/a	11,0	8,4
2011	19,7	n/a	5,0	2,1
2012	5,9	n/a	2,1	0,5
2013	22,3	n/a	6,6	2,1
2014	27,8	n/a	8,3	2,8
2015	0,5	n/a	0,2	0,0
2016	0,4	n/a	0,1	0,0
2017	3,7	n/a	1,3	0,4
2018	1,1	n/a	0,3	0,1
2019	2,2	n/a	0,9	0,3

GILLNETS

Year	Weight (t)	CV	% Gillnets Catches	% Total Catches
2011	10,6	n/a		
2012	14,3	n/a		
2013	0	n/a		
2014	0,1	n/a	0,03	0,01
2015	0,4	n/a	0,18	0,04
2016	5,0	n/a	2,47	0,49
2017	10,9	n/a	4,82	1,26
2018	2,6	n/a	1,33	0,34
2019	13,3	n/a	7,40	1,98

n/a: not available

CV: coefficient of variation

2.3.3. Length frequency - landings

Length compositions of landings are available for the main métiers/fleets from Portugal and Spain. This species is caught by fisheries from ~25 cm to ~120 cm (Figures 4 and 5).

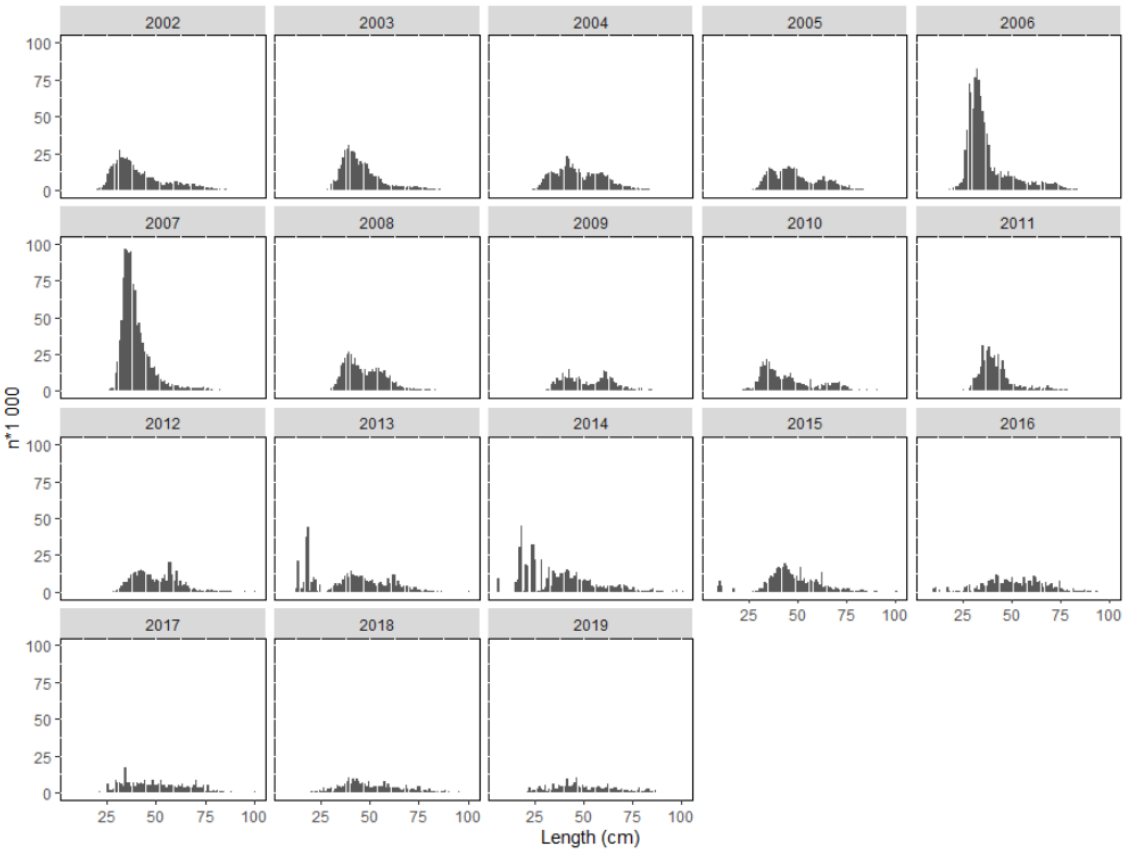

Figure 4. *Lophius budegassa* in ICES divisions 8c and 9a. Length distribution of landings (2002-2019).

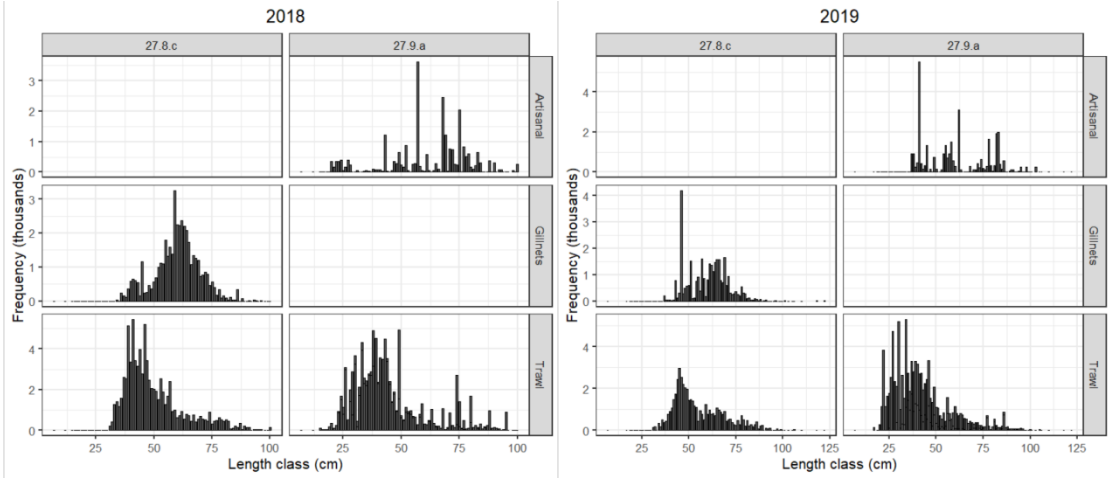

Figure 5. *Lophius budegassa* in ICES divisions 8c and 9a. Length distribution by fleet and division in 2018 and 2019.

2.3.4. CPUE and LPUE indices currently used in the assessment of ank.27.8c9a

Portuguese trawlers targeting crustaceans in Division 9a (PT-TRC9a)

CPUE data is available from the Portuguese trawlers targeting crustaceans since 1989 (Figure 6a). This fishery operates in the southwest and south coasts and represents an average of 3% of international catches of black anglerfish along the time-series. CPUE consists on the biomass caught (in kg) by hour and is estimated from logbook data. A standardized CPUE series (kg/haul) from 1989–2008 is also available for this fleet. Comparison between standardized and nominal CPUEs showed no major differences between series and the nominal series has been used in the black anglerfish assessment (Figure 7a; Cardador et al., 2008; Cardador, 2009).

Portuguese trawlers targeting fish in Division 9a (PT-TRF9a)

CPUE data is available from the Portuguese trawlers targeting fish since 1989 (Figure 6b). This fishery operates in the occidental coast and represents an average of 5% of international catches of black anglerfish along the time-series. CPUE consists on the biomass caught (in kg) by hour and is estimated from logbook data. A standardized CPUE series from 1989–2008 is also available for this fleet. Comparison between standardized and nominal CPUEs showed no major differences between series and the nominal series has been used in the black anglerfish assessment (Figure 7b; Cardador et al., 2008; Cardador, 2009).

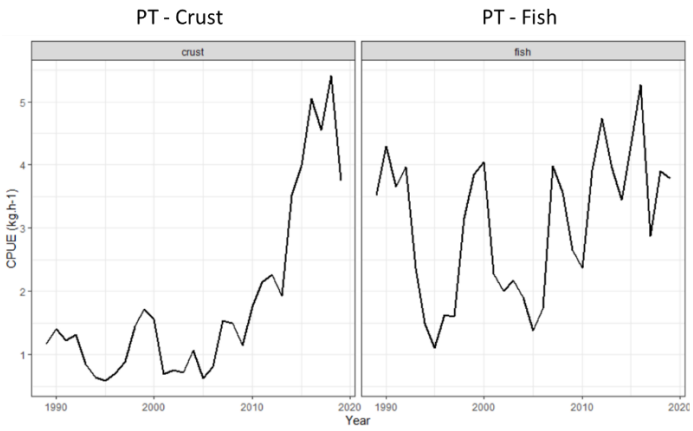

Figure 6. *Lophius budegassa* in ICES divisions 8c and 9a. Commercial CPUE from the a) Portuguese trawlers targeting crustacean (PT-TRC9a) and b) Portuguese trawlers targeting fish in Division 9.a (PT-TRF9a) (1989-2019).

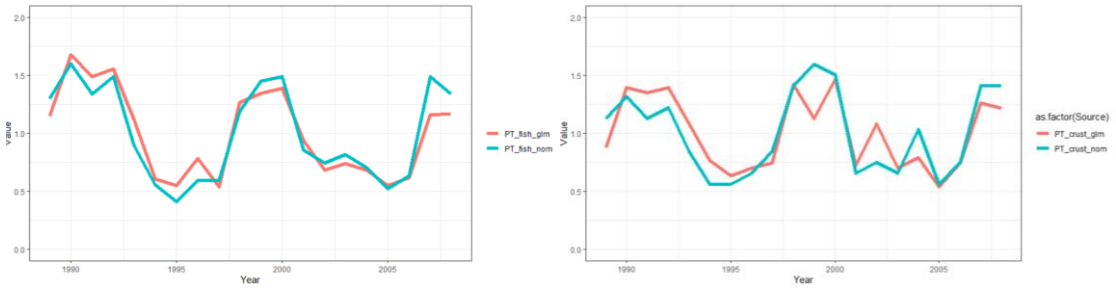

Figure 7. *Lophius budegassa* in ICES divisions 8c and 9a. Comparison between standardized and nominal CPUEs for the a) Portuguese trawlers targeting crustacean (PT-TRC9a) and b) Portuguese trawlers targeting fish in Division 9.a (PT-TRF9a) (1989-2008). A GLM was fitted to data considering as independent variables the year, quarter and vessel size category. Adapted from Cardador (2009).

Coruña Trawl Fleet in Division 8c (SP-CORTR8c)

A Coruña trawl fleet fishing in Division 8c is available for years 1982–2012 (Figure 7). Data provided for A Coruña trawlers comprise quarterly effort (fishing days per 100 horse power), and landings. This is a mixed-fishery targeting various demersal (hake, megrims, anglerfish) and pelagic species (mackerel, horse mackerel). The length composition of black anglerfish catches ranged from 30 to 80 cm. This fleet represents an average of 18% of international catches of black anglerfish along the available time-series. A standardized LPUE series from 1994–2006 is also available for this fleet with annual effort data (in fishing days). Comparison between standardized and nominal LPUE showed no major differences between series and the nominal series has been used in the black anglerfish assessment (Cardador et al., 2008).

This abundance index is used in the assessment for the period 1982–2012. The change in the source of the information and the methodology used to estimate the LPUE prevented the use of the information since 2012. The main difference between the methods used to estimate the LPUE for the Coruña Trawl Fleet in Division 8c (previous and after 2012) is related with the quantification of the effort. Until 2012, the duration of the fishing trips was a fix value of 1.5 or 2 days depending on the target species.

2.3.5. CPUE and LPUE indices to be considered for the assessment of ank.27.8c9a

Coruña Trawl Fleet in Division 8c (SP-CORTR8c)

The new information that has been reported since 2012 for the Coruña Trawl Fleet currently constitutes a 7-year series. Since 2012, the logbook's information was used to estimate the exact duration of each trip, being the effort more precisely estimated. Also, the new series of LPUE – A Coruña Port - is calculated using only the information from vessels whose official base port is A Coruña. Previously, all vessels operating regularly in A Coruña were included in the calculations. The new index (port series; 2013-2019) is presented in Figure 8, together with the fleet series index (1982-2012). The two LPUE series should not be joined and used as an only one series but can be considered as two independent LPUE series: the first one covering the period 1980-2012 and the second one for the period 2013-2019.

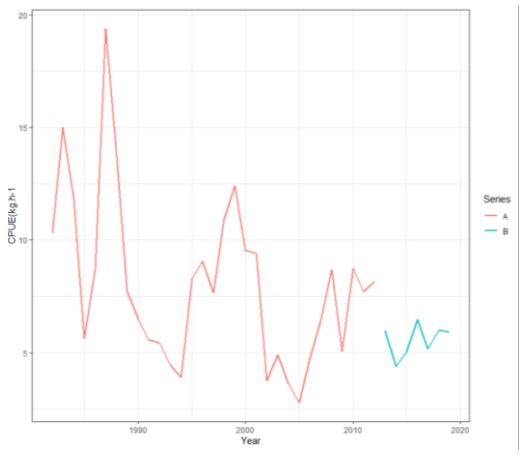

Figure 8. *Lophius budegassa* in ICES divisions 8c and 9a. Commercial LPUE for the for the Coruña Trawl Fleet in Division 8c (SP-CORTR8c): A – fleet series, used in the assessment (1982-2012); B – port series (2013-2019).

Portuguese artisanal fleet in Division 9a

Portuguese landings of black anglerfish are mainly attributed to the artisanal fleet (which represent, on average, 22% of the total catches. Within this fleet, vessels targeting both *Lophius* species with trammel nets represent 75–90% of the total catches. This fishery operates along the whole coast. A standardized CPUE series using logbook data has been developed with data from 2012 to 2019 (Figure 9; see more information in Moura, 2020 WD).

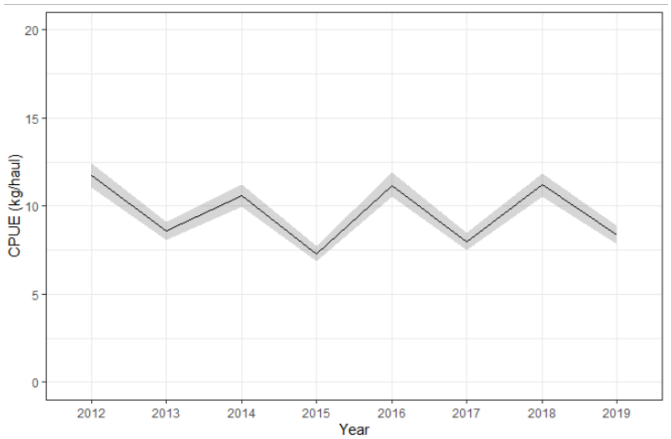

Figure 9. *Lophius budegassa* in ICES divisions 8c and 9a. Commercial LPUE for the Portuguese Artisanal fleet (trammel nets) (2012-2019).

2.3.6. LPUE indices not used/not adequate for the assessment of ank.27.8c9a

Cedeira Gillnet Fleet in Division 8c (SP-CEDGN8c)

Cedeira gillnet fleet fishing in Division 8c is available for years 1999–2011. Data provided for Cedeira gillnets comprise quarterly standardized effort (in soaking days), landings and length

composition of landings. This fleet represents only represents and average of 1% of international catches of black anglerfish since 1999. The fishery targets white anglerfish (92% of catches) and larger individuals (lengths over 60 cm). Due to the reduction in the number of vessels of Cedeira fleet, this tuning series could not be considered as a representative abundance index for this stock since 2012.

Santander trawl fleet fishing in Division 8.c (SP-SANTR8c)

Santander trawl fleet fishing in Division 8c is available for the years 1986–2010. Data provided comprise quarterly effort (fishing days per 100 horse power), landings and length composition of landings. This fleet represents on average 3% of international catches of black anglerfish, along the available time-series. Problems with the consistency of the information and the sampling level through the years prevent the use this index in the assessments.

Avilés trawl fleet in Division 8.c (SP-AVITR8c)

Avilés trawl fleet fishing in Division 8c is available for years 1986–2003. Data provided comprise quarterly effort (fishing days per 100 horse power), landings and length composition of landings. This fleet represents an average of 3% of international catches of black anglerfish along the available time-series. Problems with the consistency of the information and the sampling level through the years prevent to use this index in the assessments.

2.4. Fisheries independent data

2.4.1. Survey information and CPUE indices

The research surveys carried out in 8c and 9a cover the distribution of the stock (Figure 10). However, catchability is low in most of the surveys and the biomass indexes available are not reliable for stock assessment of this species.

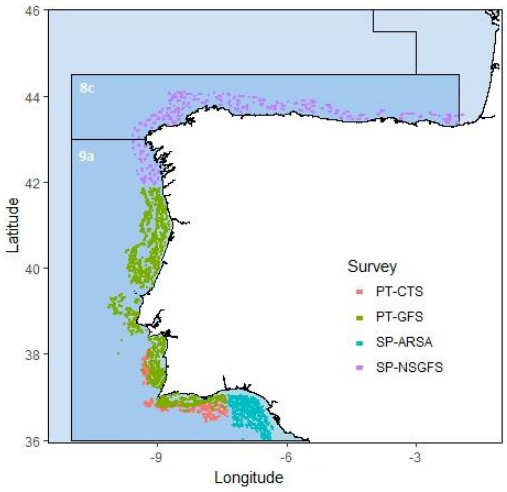

Figure 10. *Lophius budegassa* in ICES divisions 8c and 9a. Research survey distribution.

Northern Spanish Shelf Groundfish Survey in the Cantabrian Sea and Off Galicia (SP-NSGFS)

The Spanish survey SP-NSGFS covers the northern Spanish shelf comprised in ICES Division 8c and the northern part of 9a, including the Cantabrian Sea and off Galicia waters. The surveys are conducted from 30 to 800 m depth, usually starting at the end of the third quarter. Abundance index data (in number and in weight) and their associated standard deviation and length compositions are available for the period 1983–2019 with the exception of year 1987 (Figure 11). The series is annually updated and provided to the WGBIE. This survey index may be a good indicator for smaller individuals (<20 cm) abundance, but not for the exploitable part of population

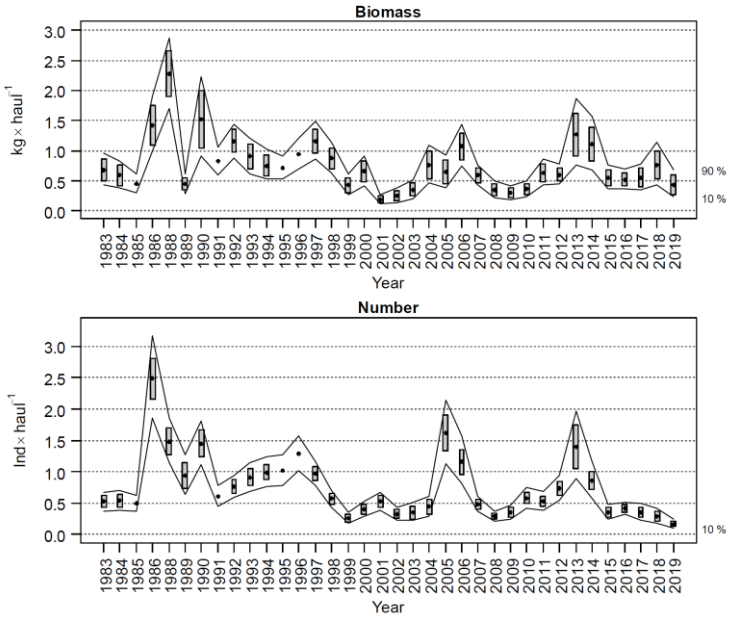

Figure 11. *Lophius budegassa* in ICES divisions 8c and 9a. Biomass and abundance indices from the Northern Spanish Shelf Groundfish Survey in the Cantabrian Sea and Off Galicia (SP-NSGFS) (1983-2019).

Southern Spanish Groundfish Survey on the Gulf of Cádiz (Southern part of Division 9a) (SP-ARSA)

The Southern Spanish Groundfish Survey on the Gulf of Cádiz is conducted in the southern part of ICES Division 9a, the Gulf of Cádiz. The covered area extends from 15 m to 800 m depth, during spring and autumn. The series covers the period 1993–2019, two surveys by year, and the abundance index (in number and in weight) and their associated variance, and length compositions are available. This survey, and particularly the Q4 survey, was identified during the WKANGLER-Data Evaluation meeting as a potential abundance index for the black anglerfish in divisions 8c9a (Figure 12). The survey catches juveniles <25 cm but also large individuals (Figure 13). However, the low spatial coverage of the stock is a concern.

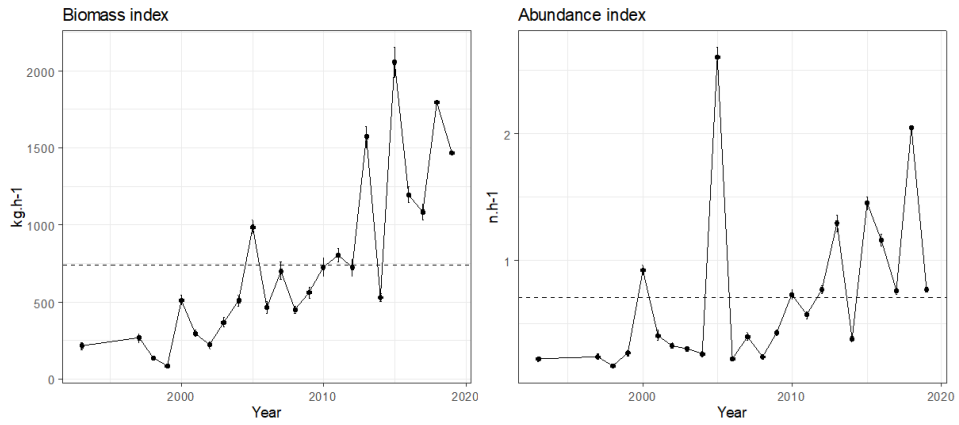

Figure 12. *Lophius budegassa* in ICES divisions 8c and 9a. Total biomass and total abundance indices for the ARSA surveys in Q4 (1997-2019).

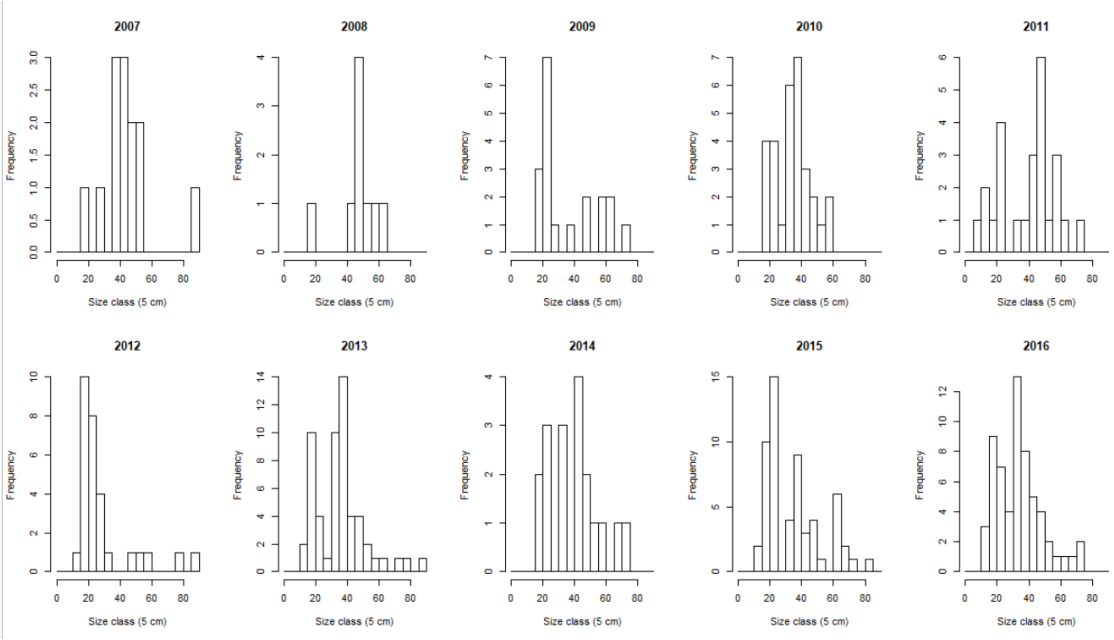

Figure 13. *Lophius budegassa* in ICES divisions 8c and 9a. Length frequency distribution in ARSA Q4 surveys (2007-2016).

Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4)

Portuguese Autumn Groundfish Survey has been carried out in Portuguese continental waters since 1979 in the fourth quarter of the years. The survey extends from latitude 41°20' N to 36°30' N (ICES Division 9.a) and from 20–500 m depth. Abundance indices are available from 1989 to 2018. The main objectives of the survey are to estimate the abundance and study the distribution of the most important commercial species in the Portuguese trawl fishery, mainly to monitor the abundance and distribution of hake and horse mackerel recruitment. The low catchability of *Lophius* on these surveys, possibly related to the gear configuration, makes this series unsuitable to assess the abundance or biomass trends of these species.

Portuguese Crustacean Survey (PT-CTS (UWTV (FU 28–29)))

The PT-CTS (UWTV (FU 28–29)) is carried out in May–July and covers the southwest coast (Alentejo or FU 28) and the south coast (Algarve or FU 29). The main objectives are to estimate the abundance, to study the distribution and the biological characteristics of the main crustacean species, namely Norway lobster, rose shrimp and red shrimp. In addition, the survey provides data for other species that have been used for stock assessment purposes. Biomass and abundance indices for *L. budegassa* are available since 1997 (Figure 14) as well as length frequency distributions (Figure 15). This survey is not used in the assessments due to the low catchabilities.

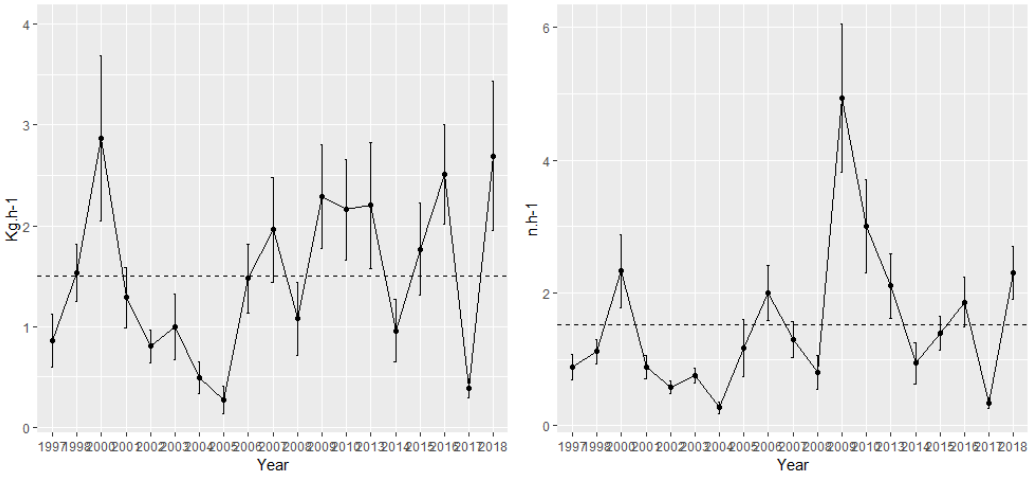

Figure 14. *Lophius budegassa* in ICES divisions 8c and 9a. Total biomass and total abundance indices for the Portuguese Crustacean Survey (PT-CTS (UWTV (FU 28–29))) (1997-2018; no survey in 2019).

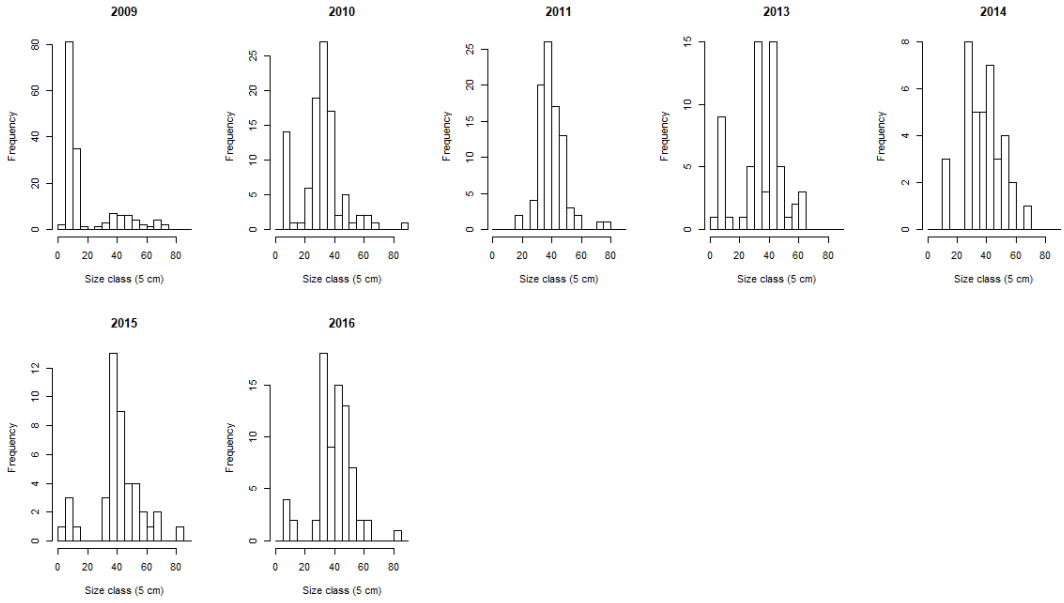

Figure 15. *Lophius budegassa* in ICES divisions 8c and 9a. Length frequency distribution in Portuguese Crustacean Survey (PT-CTS (UWTV (FU 28–29))) (2008-2016).

3. Exploratory assessments using SPiCT

Several runs were tested including the LPUE series from Portuguese commercial trawlers PT-TRC9a and PT-TRF9a, the Coruña Trawl Fleet (SP-CORTR8c), the Coruña Trawl Port data in Division and the Portuguese artisanal fleet (Table 6).

Table 6. *Lophius budegassa* in ICES divisions 8c and 9a. Summary of input data and results for each exploratory run.

	PT-TRF9a	PT-TRC9a	SP-CORTR8c (fleet)	SP-CORTR8c (port)	PT-GTR	Results and observations
Period	**1989-2019**	**1989-2019**	**1982-2012**	**2013-2019**	**2012-2019**	
Area	9a	9a	8c	8c	9a	
1	x	x	x			Autocorrelation for PT-Crust.
2	x	x	x	x	x	Autocorrelation for PT-Crust; shapiro test signif. for SP-CORTR8c (port), larger CI for F
3	x		x	x	x	Large CI for F; Autocorrelation for PT-GTR; shapiro test signif. for SP-CORTR8c
4		x	x	x	x	No issues to report

The following settings were adopted (according to the benchmarked model):

- Euler time step (years): 1/16 (default)
- Production curve shape: Schaefer
- Alpha - (Biomass observation and process errors ratio): estimated by the model (default priors).
- Beta - Catch observation and process errors ratio): estimated by the model (default priors).

A summary of the results is presented in Table 6 and some relevant plots are also presented below.

Run 1: current model (2018 Benchmark)

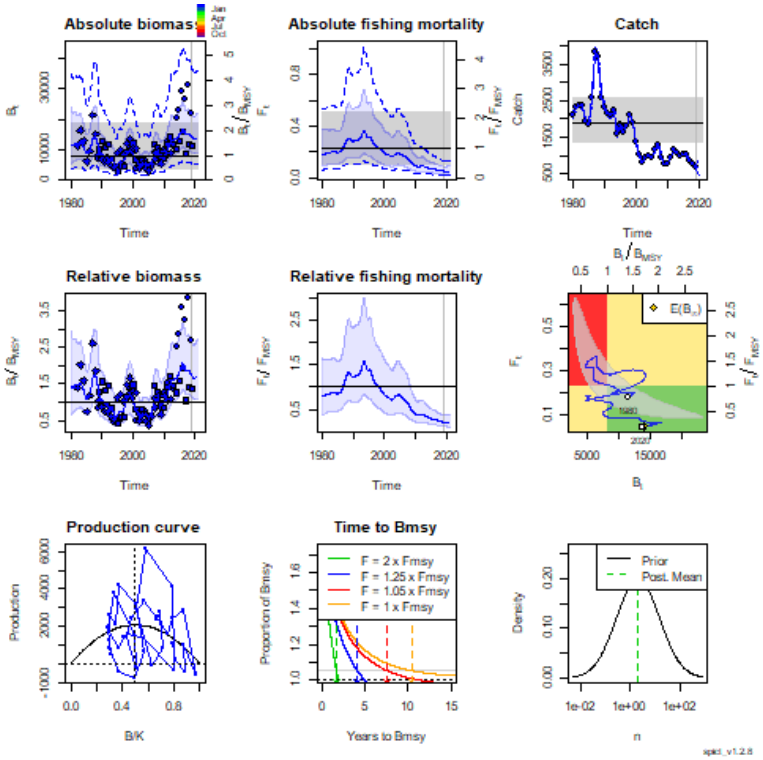

Figure 17. *Lophius budegassa* in ICES divisions 8c and 9a. SPiCT results for run 1.

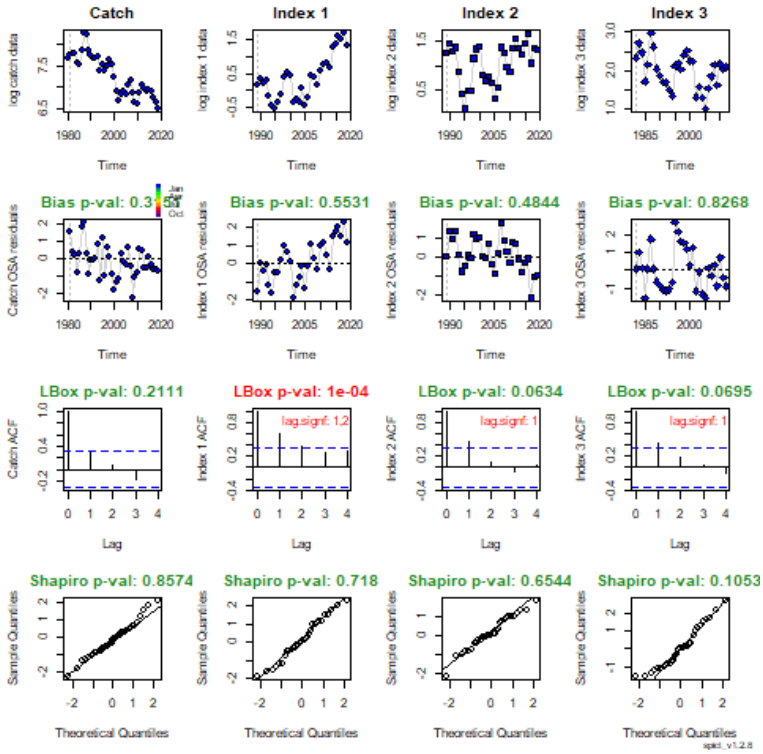

Figure 18. *Lophius budegassa* in ICES divisions 8c and 9a. Results for run 1**.** Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

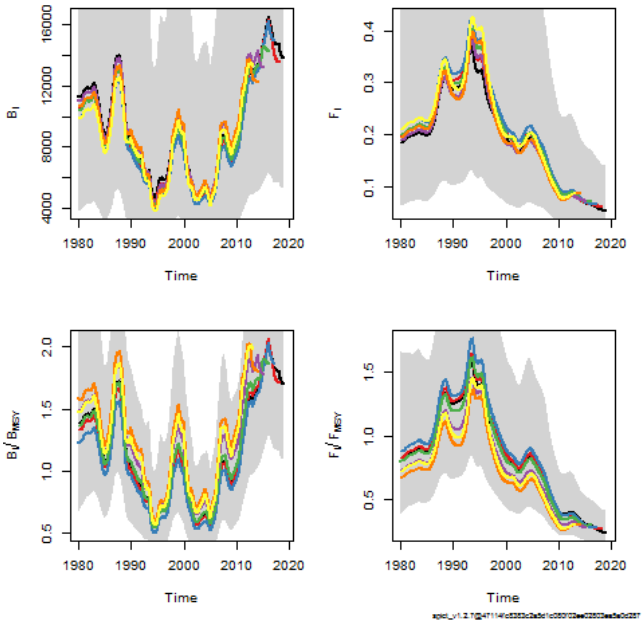

Figure 19. *Lophius budegassa* in ICES divisions 8c and 9a. Results for run 1. Retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

Run 4

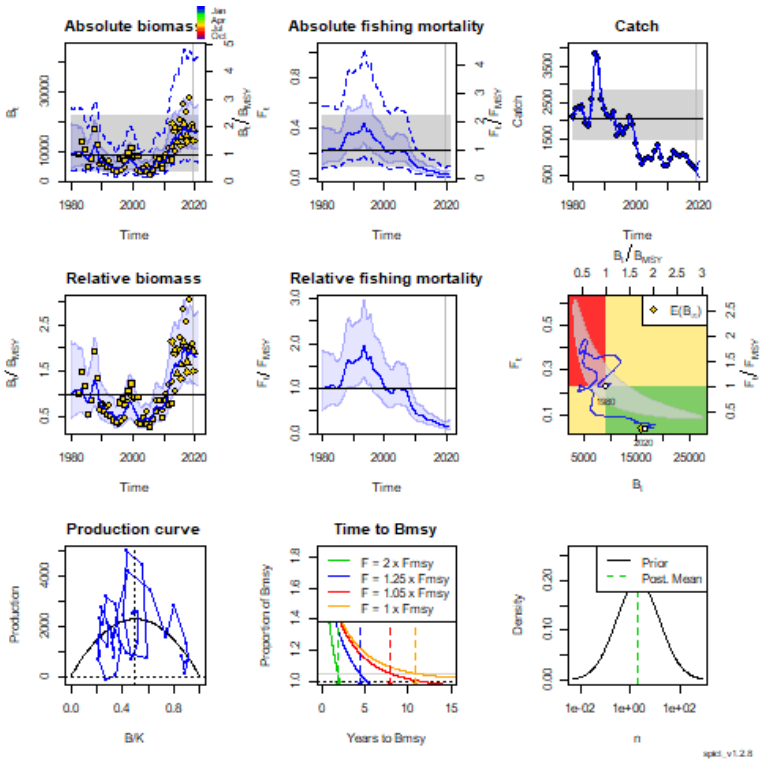

Figure 20. *Lophius budegassa* in ICES divisions 8c and 9a. SPiCT results for run 4.

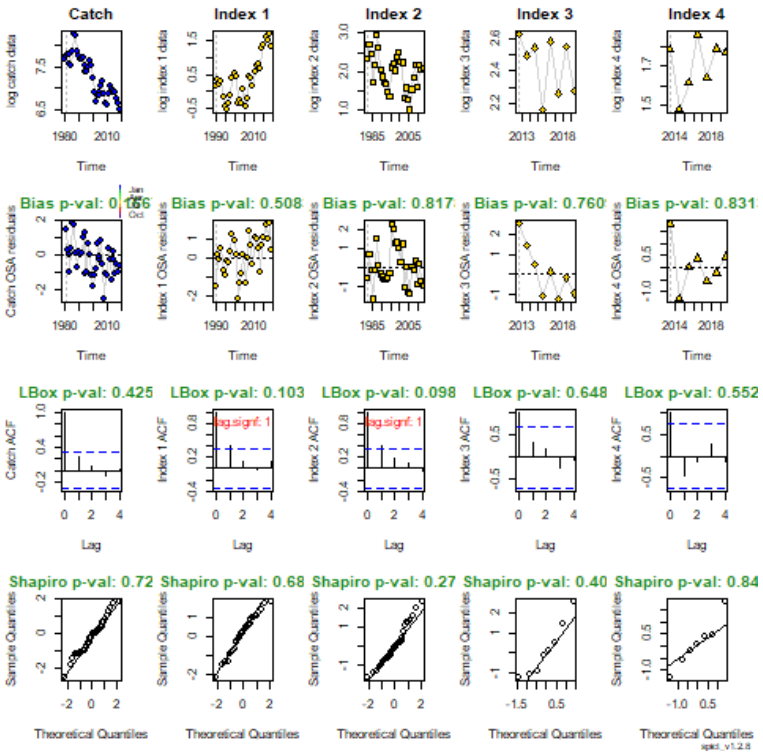

Figure 21. *Lophius budegassa* in ICES divisions 8c and 9a. Results for run 4**.** Row1, Log of the input data series. Row 2, OSA residuals with the p-value of a test for bias. Row 3, Empirical autocorrelation of the residuals with tests for significant autocorrelation. Row 4, Tests for normality of the residuals, QQ-plot and Shapiro test.

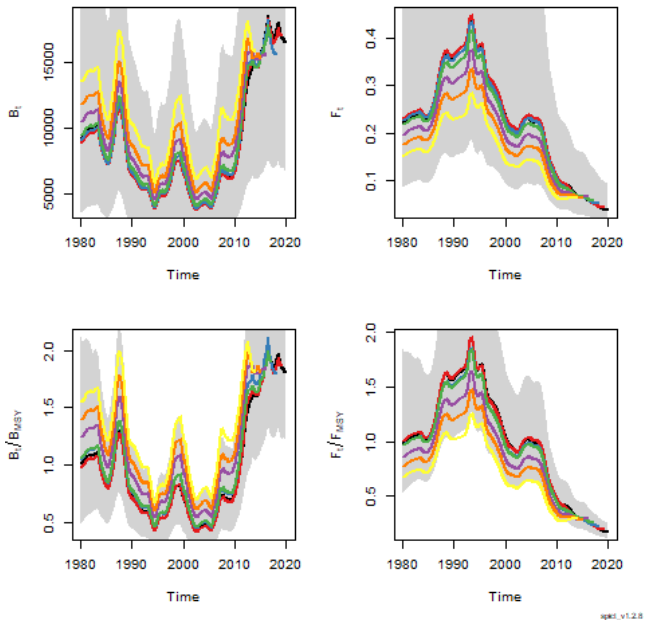

Figure 22. *Lophius budegassa* in ICES divisions 8c and 9a. Results for run 4. Retrospective analysis. Upper panel, absolute biomass and fishing mortality. Lower panel, relative biomass and fishing mortality. Grey regions represent 95% CIs.

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